PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P49296PC00		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00585	24/08/2000	24/08/1999
International Patent Classification (IPC) or national classification and IPC A61C13/00		
Applicant NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...et		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	23.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Pypen, C Telephone No. +49 89 2399 2799

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00585

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-12	as originally filed				

Claims, No.:

1-20	as received on	05/11/2001	with letter of	05/11/2001	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

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(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 20.

because:

☒ the said international application, or the said claims Nos. 20 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1-19
	No:	Claims
Inventive step (IS)	Yes:	Claims 1-19
	No:	Claims
Industrial applicability (IA)	Yes:	Claims 1-19

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No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

INTERNATIONAL PRELIMINARY EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/NL00/00585

Reference is made to the following documents:

D1: US-A-5 690 490 (BOYD GEORGE H ET AL) 25 November 1997

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 20 is a so-called "product-by-process" claim. Such claims are admissible only if the products themselves fulfil the requirements for patentability (T150/82, OJ 1984, 309). The subject-matter of claim 20, a dental element, is known from document D1 (abstract) and therefor is not new.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Document D1 (column 5, lines 47-51) discloses a method for fabricating a functional dental element, wherein a three-dimensional printing technique is used, from which the subject-matter of the independent claim 1 differs in that the element is subjected to infiltration by a second phase.

1.1. In none of the documents cited in the search report, the infiltration of the dental element with a second phase in order to enhance the material characteristics is not found, nor is this step suggested.

1.2. The subject-matter of independent claim 1 is therefore novel, involves an inventive step, and is industrially applicable (Article 33(2)-(4) PCT).

2. The independent claims 2-19 define particular embodiments of the invention according to claim 1.
Therefore, these claims also meet the requirements of Art. 33 (2)-(4)PCT, in combination with claim 1.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT - SEPARATE SHEET

International application No. PCT/NL00/00585

Re Item VII

Certain defects in the international application

1. The independent claim 1 should have been worded in the two-part form, with those features known in combination from the prior art (documents D1) being placed in the preamble and with the remaining features being included in the characterizing part (Rule 6.3(b)PCT, decision of the Board of Appeal T 13/84).

Re Item VIII

Certain observations on the international application

1. The subject-matter of the claims 1-4, 17-18 of the initial application appears to be the same as the subject-matter of the claims 1-4, 12-13 of the initial application NI00/00586.

Title: Method for making a dental element.

The invention relates to a method for making a functional dental element and to a dental element obtainable by such method.

Dental elements, such as crowns, are used in clinical practice mainly for replacing or correcting dental structures. This can involve partly or wholly lost teeth or molars. To date, materials for such elements have been examined in particular for technological/physical and chemical properties. Currently, in addition, the biological aspect plays an increasing role.

Dental elements can be fabricated from different materials. Examples include polymers, metals, composites, combinations of porcelain and metal, porcelain and other ceramic materials. Glass and ceramic materials form an ideal group of materials for dental elements, because they are hard, have a high wear resistance, are chemically inert in many media (biocompatibility), and can be simply formed into an aesthetic dental element. A broad application of these materials, however, is impeded by the inherent brittleness which is often the result of limitations in the fabricating process and of the material choice. Recent developments have led to different ceramic systems, such as sintered ceramic, glass-infiltrated ceramic and glass-ceramic of various compositions, which are less brittle.

The fabrication of dental elements in practice is a complex and time consuming affair. The products involved are fabricated on an individual basis since the exact form of the element is different for every tooth or molar in every individual. Conventional techniques that have been used often utilize a mold. Since this mold can typically be used only once, it will be clear that these techniques are very costly.

In the past, techniques have been proposed which supposedly enable simplification of the fabricating process of dental elements. Thus,

Abe et al., in Int. J. Japan Soc. Prec. Eng., vol. 30, no. 3, 1996, pp. 278-279, have proposed to carry out a selective laser sintering (SLS) with titanium. This technique, however, often gives rise to shrinkage. Also, microcracks may be formed, which renders the technique unsuitable for the fabrication of functional dental elements. In European patent application 0 311 214 it has been proposed to make a crown by milling. Milling does not provide the possibility of making colored elements. Moreover, the choice of suitable materials that can be processed by milling is limited. As noted, ceramic materials form an ideal group of materials for fabricating dental elements, because they are hard, highly wear-resistant and inert under many conditions.

U.S. Patent 5,690,490 describes a method for fabricating a concept model for a dental element by so-called pinhead molding. The method concerns the use of a kind of matrix printing technique, whereby material is sprayed on. The printer is controlled with a CAD/CAM program. The data which this program utilizes have been obtained from a laser scan of the tooth or the molar to be replaced.

In U.S. Patent 5,823,778, a method is described for the fabrication of a dental element whereby an impression of the teeth of a patient is obtained, which is subsequently used as a mold to make a copy of a dental element. This element is broken down in layers and each layer is scanned to obtain a three-dimensional computer model of the dental element.

One object of the present invention is to provide a technique whereby functional dental elements can be fabricated in a flexible and efficient manner. Another object is for the technique not to utilize a mold, and to enable making dental elements of polymeric, metallic or ceramic material, or of combinations thereof.

Surprisingly, it has presently been found that the stated objects are achieved by fabricating a dental element utilizing a three-dimensional printing technique.

Three-dimensional printing techniques are known per se, and described inter alia in European patent application 0 431 924, U.S. Patent 5,902,441 and international patent applications 94/19112, 97/26302 and 98/51747. For a description of the details of the technique, reference is made to the documents mentioned, which are therefore to be understood to be inserted herein.

The method according to the invention is in principle suitable for fabricating all types of dental elements. Examples include crowns (front and lateral teeth), inlays, overlays, onlays, partial crowns, fixations and veneers.

Preferably, in a patient in whom a dental element is to be replaced/placed, it is first accurately measured what shape the element is to have. Often, if possible, the starting point will be the shape of the tooth or molar, or the portion thereof that is to be replaced. It is preferred that measurement can take place in a manner which causes the patient as little inconvenience as possible. Particularly suitable techniques for measuring the shape for the dental element make use of optical scan techniques, in particular the use of lasers. In electronic form, data about the desired shape and dimensions are thereby obtained, which can be directly visualized in a computer. The electronic data about the shape and dimensions of the dental element are preferably used by a computer to control the execution of the three-dimensional printing technique. Another suitable method for measuring is by the CEREC-technique, Sirona Dental Systems GmbH, Bensheim, Germany.

In the three-dimensional printing technique, a suitable material is applied successively in layers, while specific steps are taken to ensure that each layer adheres to the preceding layer only at particular desired points. These specific steps are determined by the desired shape of the dental element and preferably controlled by the above-mentioned electronic data.

According to the invention, in the specific steps mentioned, use is made of a binder. This binder is applied to a preceding layer only at the

desired specific points. When to the binder a layer of, for instance, ceramic material from which the dental element is to be shaped, is applied, this will adhere only to the desired points. The non-adhering powder, which, accordingly, does not come into contact with the binder, can be simply removed.

The binder is preferably applied to the desired points by means of a print head, controlled by the computer on the basis of the data obtained upon measurement. Thereafter, a powder of the material that has been selected for the fabrication of the dental element is applied.

It is also possible to work upside down and to provide a layer of binder on the bottom side of a plate and subsequently to dip the binder in the powder. In this last variant, in a simple manner, different kinds of powder can be used for different layers. In both cases, the powder will bind only at points where binder has been applied. By repeating these steps sufficiently often, eventually the desired shape of the dental element is obtained. Finally, the binder can be removed by sintering.

According to an alternative to this method, first loose powder is laid in a powder bed, and thereafter binder is applied locally to obtain binding at the desired points. So, in fact, binder and powder can be applied in any sequential order.

The substrate on which work is done can be formed by a few layers of loose powder, so that the dental element to be formed can be readily detached from the substrate. In sintering, preferably a non-adhering substrate, for instance a metal plate, is used.

By virtue of the accuracy of the data that can be obtained by measuring with the aid of a laser technique, and by virtue of the accuracy with which a computer, on the basis of those data, can control a print head, the desired shape and dimensions of the dental element can be obtained in a highly accurate manner. While in the old-fashioned techniques it was necessary to additionally shape a dental element several times after it had

been formed in a mold, in the method according to the invention it normally suffices to carry out additional shaping a single time. Depending on the material that has been selected for the dental element, this additional shaping can be carried out by grinding, filing, polishing, sanding, blasting or by using a ball bed (a vibrating box containing abrasive balls).

The binder that is used in a method according to the invention should be soluble in a suitable solvent to a solution having a viscosity of 1-40 mPas, preferably about 3 mPas, and a loading degree of 3-10 wt.%. Thus the binder preferably has a relatively low molecular weight. Examples of suitable binders are colloidal silica, polyvinyl acetate (PVA), starch adhesives, acrylates, polyvinyl alcohol, polyethylene oxide (PEO), ethylenevinyl acetate (EVA) and derivatives thereof.

In the binder, often a colorant will be used. Suitable colorants are normally based on inorganic pigments having a high content of SiO_2, which renders them heat-resistant. These substances are known per se and commercially available, for instance, from Carmen, Espridient GmbH, Ispringen, Germany, or VITA Zahnfabrik H. Rauter GmbH & co., Bad Zäckingen, Germany. Preferably, one or more of the following colorants are used: SiO, CoO, ZnO, Cr_2O_3, TiO_2, Sb_2O_3, Fe_2O_3 and MnO_2. Depending on the desired dental color, colorants are preferably used in amounts of up to 10% by weight, based on the weight of the powder. It is a particular advantage of the invention that at different points in the dental element, different colors can be used, if desired with a transparent outer layer, yielding a natural optical depth action. By virtue of these and other advantages, a dental element resembles a real tooth or molar extremely faithfully.

As noted, this binder can be applied to a suitable substrate with a print head. The print head is controlled by a computer on the basis of the data which have been obtained through prior measurements on the patient for the purpose of the dental element. Examples of suitable print heads are,

for instance, inkjet heads of the continuous or of the drop-on-demand type. The print head preferably has a spray nozzle of a diameter between 10 and 100 μm, more preferably between 25 and 75 μm and a length between 50 and 150 μm.

The powder that is used is selected on the basis of the material of which the dental element is eventually to be made. The powder can be used both in dry form and in dispersed form (slurry). Dispersions are preferably prepared in water or an aqueous solution. In addition, some organic solvents, such as isopropanol, can be used. The skilled person will be able to choose a suitable solvent on the basis of his normal knowledge. Depending on the particle size of the powder, it may be desirable to prepare a colloidal solution of the powder, for instance by addition of a base, salt and/or surfactant. When the powder is applied in dispersed form, preferably a drying step takes place each time before a next layer is applied.

According to a preferred embodiment of the invention, in each layer, several materials, of a different nature, are used. It is also possible, and highly favorable under certain circumstances, to modify the composition of the powder per layer to be applied. If per layer one type of material is applied, often a doctor blade (slurry) or counter rotating roller (dry powder) is used. If per layer more than one type of material is applied, this is applied locally, preferably by means of one or more computer-controlled nozzles capable of applying one or several materials. The materials can differ from each other in color or in properties. To be considered here are, for instance, (di)electric or piezoelectric properties. According to this embodiment, the material is preferably applied in the form of a slurry.

According to the invention, different kinds of materials, in particular both ceramic materials and metals, can be used. To be able to properly apply the material to the binder, the material is preferably in powder form. Depending on the size of the powder particles, the powder will

be applied in dry form or in dispersed form (slurry). A finer powder leads to a greater accuracy in achieving the desired shape of the dental element. Preferably, the powder has an average particle size (diameter) between 1 nm and 50 μm, more preferably smaller than 50 nm, still more preferably between 10 nm and 25 nm. The advantage of this is that sintering can be carried out in a short time and at a relatively low temperature. It has been found that the particle size referred to has a positive effect on the shape and sinterability of the dental element to be formed.

The powder can be made of any material that is conventionally used for forming dental elements. For this purpose, in particular metals and ceramic materials and combinations thereof are suitable.

When a ceramic material is used for forming the dental element, this is preferably selected from the group of SiO_2, Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O and combinations thereof. Optionally, ceramic compositions can further contain F or P_2O_5. Particularly suitable ceramic materials are the commercially available compositions Vitadur®, IPS Empress®, Dicor®, IPS Empress II®, Cerestone®, CerePearl® and In-Ceram®.

When a metal is used for forming the dental element, this is preferably selected from the group of alloys of gold, platinum, palladium, nickel, chromium, iron, aluminum, molybdenum, beryllium, copper, magnesium, cobalt and tin. Optionally, such an alloy can contain silicon. For a description of suitable alloys, reference is made to J.P. Moffa, Alternatives to Gold Alloys in Dentistry, DHEW Publication N. (NIH), 77-1227.

If desired, a lubricant can be added to the powder to facilitate applying the powder in layers. Examples of suitable lubricants are stearic acid or derived stearates, such as zinc or calcium stearate. A lubricant is preferably used in an amount of 1-2% by weight, based on the weight of the powder.

As mentioned, preferably, in alternation a layer of binder is applied and a layer of powder is applied thereto. The thickness of the layers of powder is preferably between 0.01 and 0.3 mm, more preferably between 20 and 100 μm, which is beneficial to the surface quality in the case of slight differences in height contour of the layers. The amount of binder per unit area of powder is fairly critical, but can simply be adjusted by a skilled person to the nature of the binder and powder used. Normally, the amount of binder will be between 0.005 and 0.3 grams per square centimeter of powder. Thus, layer by layer the desired dental element is built up.

When the last layer has been applied, excess powder which has not been bound is removed. This can be done by taking out the entire powder bed, turning it upside down and shaking gently. Residues can be removed by blowing, for instance with compressed air. Thereafter the powder particles can be bonded together by sintering. Preferably, prior to sintering, a debinding step is carried out, i.e., a treatment to remove the binder. Debinding can be carried out by means of heat or a suitable solvent, such as hexane. Because most binders have a relatively complex composition, debinding preferably takes place by heating using a temperature path (for instance from 20 to 500°C). Such a heating scheme can be simply coupled to a sintering step.

The duration and temperature at which sintering takes place will depend on the nature of the binder used and the powder. Normally, the duration of sintering will be between 10 minutes and 3 hours, while the temperature will typically be between 400 and 800°C. By sintering in such a way that only necks are formed, shrinkage due to the sintering step is minimal/negligible. Optionally, such shrinkage can be compensated by scaling the CAD model.

After sintering, the product obtained is preferably infiltrated, whereby a second phase is introduced into the product. As a result, the porosity of the product is considerably reduced. Densities in excess of 99%

are feasible. The infiltration can be carried out, for instance, in an oven, whereby the infiltration material is laid against the dental element. The infiltration material melts at a lower temperature than the material of the dental element. Through capillary action, the liquid infiltration material is infused (adsorbed). This step lasts a relatively short time and gives the dental element the desired properties. A suitable material for this is, for instance, glass-ceramic or a polymer. Preferably, a material is used which has been approved for use in dental elements, as described in the standard ADA no. 15 ANSY MD156.15-1962, which is to be understood to be inserted herein.

In particular cases, it has been found to be advantageous to subject the dental element to a thermal/chemical post-treatment, so that an optimum material (micro)structure is achieved. Thus, preferably, the dental element is briefly heated to a temperature between 60 and 150°C, more preferably between 80 and 130°C.

Instead thereof, or supplemental thereto, preferably a thermal compaction is accomplished. To that end, the dental element is heated to a temperature of at least 250°C, preferably at least 400°C and more preferably at least 500°C. This treatment contributes to the dental element obtaining particularly favorable properties.

When by one of the procedures described above the dental element has been formed, it may happen that it still needs to be additionally shaped to some extent. As has already been indicated, it is an advantage of the invention that it enables work to be done very accurately. Additional shaping will therefore be less laborious than in the techniques used heretofore. Ways in which additional shaping can be carried out include inter alia grinding, filing, polishing, sanding, blasting or treatment with a ball bed, depending on the selected material of the dental element.

The invention will presently be elucidated in and by the following examples.

Example 1

Two binders were prepared, having the following compositions:

A:	- polyvinyl acetate (Optapix PA 4 G)	2 wt.%
	- alcohol content (ethanol)	36 wt.%
	- glycol	2 wt.%
	- water	balance
B:	- polyvinyl acetate (Optapix PA 4 G)	2 wt.%
	- alcohol content (ethanol)	34 wt.%
	- glycol	1 wt.%
	- water	balance.

The compositions were prepared by manually adding the ingredients and stirring. Dissolving the polyvinyl acetate took 6 to 10 hours. Through the alcohol content, the surface tension could be set (a low surface tension proved favorable).

Example 2

With a bindjet printer (Z402 of the firm Z Corporation, Burlington MA USA) two cylinders were fabricated, using aluminum powder (type CT 3000SG) in combination with, successively, binder A and binder B (see Example 1). The properties of the powder are as follows:

Table 1: Chemical purity (% by weight)

Al_2O_3	>= 99.7
Na_2O	0.09
SiO_2	0.02
Fe_2O_3	0.02
CaO	0.02
MgO	0.10

Physical properties of the powder:

- Specific surface energy range BET:

5.5 to 7.5 m^2/g

- Median particle size (MPS) d50:

0.5 to 0.7 μm Cilas 850

- Particle size d90:

1.0 to 2.0 μm Cilas 850

Ceramic properties of the powder:

- Green density: 2.22 g/cm^3
- Sintered density: 3.90 g/cm^3
- Shrinkage: 16.5%

The alumina powder is distributed homogeneously over the building platform by means of a divider (kind of razor blade/snow shovel/doctor blade). Thereafter, the layer of loose powder applied is compacted with a coated roller (teflon roller with polyester top layer), so that a smooth and flat layer of loose powder is formed (like flattened castor sugar). Through this compaction step, the initial porosity is rendered substantially lower, which is beneficial to the so-called green strength. The layer thickness of this powder layer is adjustable and has been set at 0.0625 mm (the size of this step determines the accuracy of following the product contours, and may be still smaller).

After the entire building surface has been provided with a new compacted powder layer, binder is locally applied to the loose powder by means of a binder jet printer (Z402 of the firm Z Corp., see also WO-A-97/26302). The location where the binder substance is to be printed has been determined beforehand by software. The binder penetrates so deeply into the loose powder that the powder particles in the new layer are bound to each other and that further the new layer is bonded to the preceding one.

With the cartridge and binder substance used, an optimum in binder amount has been found to be 10x printing per 100 g. The amount of binder at a given layer thickness is 0.0017 g/cm^2 per inkjet run. Accordingly, at 10x ink jetting this is 0.017 g/cm^2, which leads to a good consistency of the products (they can be handled).

By repeating the recoating and inkjet steps, eventually the entire product is built up in the green (= with binder) form.

The cylindrical products which have been produced had a diameter of 16.4 mm and a height of 18 mm; the mass is 5.3 g. The experiments were carried out in triplicate. The porosity of the alumina cylinders is 45% at a maximum (in the absence of compacting). Compacting leads to a lower porosity (estimate 55 – 70%).

The intermediate products were subsequently subjected to debinding and sintering according to a specific temperature-time path, whereby heating was done at a rate of 120°C per hour to a temperature of 1200°C. This temperature was maintained for 120 minutes, followed by cooling to room temperature, again at a rate of 120°C per hour. The sintered products were subsequently infiltrated with a glass ceramic to obtain the eventual strength and mechanical properties. The obtained properties satisfy the standard imposed on the functional dental elements.

CLAIMS

1. A method for fabricating a functional dental element, wherein a three-dimensional printing technique is used.

2. A method according to claim 1, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

3. A method according to claim 2, wherein the laser technique yields data about shape and dimensions in electronic form.

4. A method according to any one of the preceding claims, wherein layers of a suitable material are successively applied onto each other, while measures are taken, such that each layer adheres at desired positions to a preceding layer, and excess, non-adhering material is removed.

5. A method according to claim 4, wherein the suitable material is a powder and wherein the bonding between the layers is realized by means of a binder.

6. A method according to claim 5, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a print head which applies the binder to specific, desired positions.

7. A method according to claim 5 or 6, wherein the binder is selected from the group of colloidal silica, polyvinyl acetate (PVA), starch adhesives, acrylates, polyvinyl alcohol, polyethylene oxide (PEO), ethylenevinyl acetate (EVA) and derivatives thereof.

8. A method according to claims 5-7, wherein the powder is selected from the group of ceramic materials, such as SiO_2, Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O and combinations thereof, and metals, such as alloys of gold, platinum, palladium, nickel, chromium, iron, aluminum, molybdenum, beryllium, copper, magnesium, cobalt and tin, and combinations of metals and ceramic materials.

9. A method according to any one of claims 5-8, wherein the layers are applied with a doctor blade.

10. A method according to claims 5-9, wherein the powder is applied in dispersed form.

11. A method according to claim 10, wherein in a layer, powders of a different nature are used.

12. A method according to claim 11, wherein in a layer, powders of a different color are used.

13. A method according to claims 10-12, wherein at least one layer differs in composition from the others.

14. A method according to claims 11-13, wherein the powder is locally applied with a computer-controlled nozzle.

15. A method according to claims 5-14, wherein the dental element is sintered at a temperature of 400-800 °C for a period between 10 minutes and 3 hours.

16. A method according to claim 15, wherein after sintering an infiltration with glass-ceramic or a polymer is carried out.

17. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

18. A dental element obtainable by a method according to any one of the preceding claims.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00585

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C13/00 B29C67/00 A61K6/083

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61C B29C A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 690 490 A (BOYD GEORGE H ET AL) 25 November 1997 (1997-11-25) cited in the application column 4, line 30-46 column 5, line 19-22 column 5, line 35-61 figures 4,7	1-4,17, 18
A	---	5,6,14
X	US 5 902 441 A (BREDT JAMES F ET AL) 11 May 1999 (1999-05-11) cited in the application column 1, line 44-48 column 2, line 24-38 figure 2	1
A	---	6
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 November 2000	05/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chabus, H

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 823 778 A (SCHMITT STEPHEN M ET AL) 20 October 1998 (1998-10-20) cited in the application column 2, line 21-28	1
A	EP 0 431 924 A (MASSACHUSETTS INST TECHNOLOGY) 12 June 1991 (1991-06-12) cited in the application column 3, line 22-38 column 11, line 15-18	5-8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 00/00585

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5690490 A	25-11-1997	NONE	
US 5902441 A	11-05-1999	DE 29724176 U	13-04-2000
		EP 0925169 A	30-06-1999
		JP 2000505737 T	16-05-2000
		WO 9809798 A	12-03-1998
US 5823778 A	20-10-1998	NONE	
EP 0431924 A	12-06-1991	US 5204055 A	20-04-1993
		CA 2031562 A,C	09-06-1991
		DE 69025147 D	14-03-1996
		DE 69025147 T	05-09-1996
		JP 2729110 B	18-03-1998
		JP 6218712 A	09-08-1994
		US 5340656 A	23-08-1994
		US 6036777 A	14-03-2000
		US 5807437 A	15-09-1998
		US 5387380 A	07-02-1995

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
VEREENIGDE
Attn. PRINS, Ir. A. W.
Nieuwe Parklaan 97
NL-2587 BN The Hague
NETHERLANDS

Kopie in/naar | TERMIJN
0 4 DEC. 2000

Beantwoord voorl. def. | bericht gezonden aan

MAP

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

NRF 24-4-2001

(PCT Rule 44.1)

Prel. ex. 24-3-2001 Gum

Applicant's or agent's file reference P49296PC00	Date of mailing (day/month/year) 05/12/2000
	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/NL 00/ 00585	International filing date (day/month/year) 24/08/2000

RECEIVED
NOV - 8 2002
TECHNOLOGY CENTER R370

Applicant
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46).

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

RECEIVED
NOV 13 2002
TC 1700

RECEIVED
JUN 20 2002
TECHNOLOGY CENTER R3700

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

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TC 1700

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Luis-Miguel Paredes Sanchez

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the International application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
P49296PC00		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/NL 00/ 00585	24/08/2000	24/08/1999
Applicant		
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00585

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C13/00 B29C67/00 A61K6/083

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61C B29C A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 690 490 A (BOYD GEORGE H ET AL) 25 November 1997 (1997-11-25) cited in the application column 4, line 30-46 column 5, line 19-22 column 5, line 35-61 figures 4,7	1-4,17, 18
A	---	5,6,14
X	US 5 902 441 A (BREDT JAMES F ET AL) 11 May 1999 (1999-05-11) cited in the application column 1, line 44-48 column 2, line 24-38 figure 2	1
A	---	6
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 November 2000	05/12/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chabus, H

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/NL 00/00585

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 823 778 A (SCHMITT STEPHEN M ET AL) 20 October 1998 (1998-10-20) cited in the application column 2, line 21-28	1
A	EP 0 431 924 A (MASSACHUSETTS INST TECHNOLOGY) 12 June 1991 (1991-06-12) cited in the application column 3, line 22-38 column 11, line 15-18	5-8

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 00/00585

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5690490	A	25-11-1997	NONE		
US 5902441	A	11-05-1999	DE	29724176 U	13-04-2000
			EP	0925169 A	30-06-1999
			JP	2000505737 T	16-05-2000
			WO	9809798 A	12-03-1998
US 5823778	A	20-10-1998	NONE		
EP 0431924	A	12-06-1991	US	5204055 A	20-04-1993
			CA	2031562 A,C	09-06-1991
			DE	69025147 D	14-03-1996
			DE	69025147 T	05-09-1996
			JP	2729110 B	18-03-1998
			JP	6218712 A	09-08-1994
			US	5340656 A	23-08-1994
			US	6036777 A	14-03-2000
			US	5807437 A	15-09-1998
			US	5387380 A	07-02-1995

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
P49296PC00		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/NL 00/ 00585	24/08/2000	24/08/1999
Applicant		
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. _____

   [ ] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

PATENT COOPERATION TREATY

KB

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

PRINS, Ir. A. W.
VEREENIGDE
Nieuwe Parklaan 97
NL-2587 BN The Hague
PAYS-BAS

TERMIJN
17 NOV 2001

Beantwoord
Voorl.
def.
MAP

Bericht gezonden
aan
dd.

Applicant's or agent's file reference
P49296PC00

PCT

NRF2 24-2-2002

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of mailing *(day/month/year)*	23.11.2001
IMPORTANT NOTIFICATION	

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00585	24/08/2000	24/08/1999

Applicant
NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...et

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/

European Patent Office
D-80298 Munich
Tel. +49 89 2399 - 0 Tx: 523656 epmu d
Fax: +49 89 2399 - 4465

Authorized officer

Terzic, K

Tel.+49 89 2399-2052

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P49296PC00		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00585	24/08/2000	24/08/1999
International Patent Classification (IPC) or national classification and IPC A61C13/00		
Applicant NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...et		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	23.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Pypen, C Telephone No. +49 89 2399 2799

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00585

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-12	as originally filed				

Claims, No.:

1-20	as received on	05/11/2001	with letter of	05/11/2001

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 20.

because:

☒ the said international application, or the said claims Nos. 20 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-19
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-19
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-19

No: Claims

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Reference is made to the following documents:

D1: US-A-5 690 490 (BOYD GEORGE H ET AL) 25 November 1997

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 20 is a so-called "product-by-process" claim. Such claims are admissible only if the products themselves fulfil the requirements for patentability (T150/82, OJ 1984, 309). The subject-matter of claim 20, a dental element, is known from document D1 (abstract) and therefor is not new.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Document D1 (column 5, lines 47-51) discloses a method for fabricating a functional dental element, wherein a three-dimensional printing technique is used, from which the subject-matter of the independent claim 1 differs in that the element is subjected to infiltration by a second phase.

1.1. In none of the documents cited in the search report, the infiltration of the dental element with a second phase in order to enhance the material characteristics is not found, nor is this step suggested.

1.2. The subject-matter of independent claim 1 is therefore novel, involves an inventive step, and is industrially applicable (Article 33(2)-(4) PCT).

2. The independent claims 2-19 define particular embodiments of the invention according to claim 1.
Therefore, these claims also meet the requirements of Art. 33 (2)-(4)PCT, in combination with claim 1.

Re Item VII

Certain defects in the international application

1. The independent claim 1 should have been worded in the two-part form, with those features known in combination from the prior art (documents D1) being placed in the preamble and with the remaining features being included in the characterizing part (Rule 6.3(b)PCT, decision of the Board of Appeal T 13/84).

Re Item VIII

Certain observations on the international application

1. The subject-matter of the claims 1-4, 17-18 of the initial application appears to be the same as the subject-matter of the claims 1-4, 12-13 of the initial application NI00/00586.

Amended Claims

1. A method for fabricating a functional dental element, wherein a three-dimensional printing technique is used and wherein the element is subjected to infiltration by a second phase.

2. A method according to claim 1, wherein the infiltration is preceded by a debinding step and/or a sintering step.

3. A method according to claim 1 or 2, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

4. A method according to claim 3, wherein the laser technique yields data about shape and dimensions in electronic form.

5. A method according to any one of the preceding claims, wherein layers of a suitable material are successively applied onto each other by three-dimensional printing and wherein each layer is bonded at desired positions to a preceding layer thereby allowing the removal of excess, non-adhering material.

6. A method according to claim 5, wherein the suitable material is a powder and wherein the bonding between the layers is realized by means of a binder.

7. A method according to claim 6, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a print head which applies the binder to specific, desired positions.

8. A method according to claim 6 or 7, wherein the binder is selected from the group of colloidal silica, polyvinyl acetate (PVA), starch adhesives, acrylates, polyvinyl alcohol, polyethylene oxide (PEO), ethylenevinyl acetate (EVA) and derivatives thereof.

9. A method according to claims 6-8, wherein the powder is selected from the group of ceramic materials, such as SiO_2, Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O and combinations thereof, and metals, such as alloys of gold, platinum, palladium, nickel, chromium, iron, aluminum, molybdenum,

beryllium, copper, magnesium, cobalt and tin, and combinations of metals and ceramic materials.

10. A method according to any one of claims 6-9, wherein the layers are applied with a doctor blade.

11. A method according to claims 6-10, wherein the powder is applied in dispersed form.

12. A method according to claim 11, wherein in a layer, powders of a different nature are used.

13. A method according to claim 12, wherein in a layer, powders of a different color are used.

14. A method according to claims 11-13, wherein at least one layer differs in composition from the others.

15. A method according to claims 12-14, wherein the powder is locally applied with a computer-controlled nozzle.

16. A method according to claims 12-15, wherein at least one of the powders has an average particle size less than 50 nm.

17. A method according to any one of the preceding claims, wherein the dental element is sintered at a temperature of 400-800 °C for a period between 10 minutes and 3 hours.

18. A method according to claim 17, wherein after sintering an infiltration with a glass-ceramic or a polymer is carried out.

19. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

20. A dental element obtainable by a method according to any one of the preceding claims.

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

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International Application No. PCT/NL 0 0 / 0 0 5 8 5

International Filing Date 24 AUG 2000 (24.08.00)

BUREAU VOOR DE INDUSTRIËLE EIGENDOM
P.C.T. INTERNATIONAL APPLICATION

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* P49296PC00

Box No. I TITLE OF INVENTION

Method for making a dental element

Box No. II APPLICANT

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk
Onderzoek TNO
Schoemakerstraat 97
2628 VK Delft
The Netherlands

☐ This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State *(that is, country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of: ☐ all designated States ☒ all designated States except the United States of America ☐ the United States of America only ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

Feenstra, Frits Kornelis
Rosa Manuslaan 48
2642 DR Pijnacker
The Netherlands

This person is:

☐ applicant only

☒ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

State *(that is,country)* of nationality: NL

State *(that is, country)* of residence: NL

This person is applicant for the purposes of: ☐ all designated States ☐ all designated States except the United States of America ☒ the United States of America only ☐ the States indicated in the Supplemental Box

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

Mr Ir A.W. Prins, c.s.

c/o VEREENIGDE
Nieuwe Parklaan 97
2587 BN The Hague
The Netherlands

Telephone No. 070-4166711

Facsimile No. 070-4166799

Teleprinter No.

RO/NL

☐ **Adress for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

See Notes to the request form

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) *(mark the applicable check-boxes; at least one must be marked)*:

Regional Patent

☒ **AP** **ARIPO Patent:** **GH** Ghana, **GM** Gambia, **KE** Kenya, **LS** Lesotho, **MW** Malawi, **MZ** Mozambique, **SD** Sudan, **SL** Sierra Leone, **SZ** Swaziland, **TZ** United Republic of Tanzania, **UG** Uganda, **ZW** Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

☒ **EA** **Eurasian Patent:** **AM** Armenia, **AZ** Azerbaijan, **BY** Belarus, **KG** Kyrgyzstan, **KZ** Kazakhstan, **MD** Republic of Moldova, **RU** Russian Federation, **TJ** Tajikistan, **TM** Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

☒ **EP** **European Patent:** **AT** Austria, **BE** Belgium, **CH and LI** Switzerland and Liechtenstein, **CY** Cyprus, **DE** Germany, **DK** Denmark, **ES** Spain, **FI** Finland, **FR** France, **GB** United Kingdom, **GR** Greece, **IE** Ireland, **IT** Italy, **LU** Luxembourg, **MC** Monaco, **NL** Netherlands, **PT** Portugal, **SE** Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

☒ **OA** **OAPI Patent:** **BF** Burkina Faso, **BJ** Benin, **CF** Central African Republic, **CG** Congo, **CI** Côte d'Ivoire, **CM** Cameroon, **GA** Gabon, **GN** Guinea, **GW** Guinea-Bissau, **ML** Mali, **MR** Mauritania, **NE** Niger, **SN** Senegal, **TD** Chad, **TG** Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT *(if other kind of protection or treatment desired, specify on dotted line)* .....

National Patent *(if other kind of protection or treatment desired, specify on dotted line)*:

☒ **AE** United Arab Emirates
☒ **AG** Antigua and Barbuda
☒ **AL** Albania .....
☒ **AM** Armenia .....
☒ **AT** Austria .....
☒ **AU** Australia .....
☒ **AZ** Azerbaijan
☒ **BA** Bosnia and Herzegovina .....
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☒ **CA** Canada
☒ **CH and LI** Switzerland and Liechtenstein
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☒ **CR** Costa Rica .....
☒ **CU** Cuba .....
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☒ **MD** Republic of Moldova .....
☒ **MG** Madagascar .....
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Check-box reserved for designating States which have become party to the PCT after issuance of this sheet:

☐ .....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. *(Confirmation (including fees) must reach the receiving Office within the 15-month time limit.)*

See Notes to the request form

Box No. VI PRIORITY CLAIM ☐ Further priority claims are indicated in the Supplemental Box.

Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is: national application: country	regional application:* regional Office	international application: receiving Office
item (1) (24.08.99) 24 August 1999	1012897	NL		
item (2)				
item (3)				

☒ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office)* identified above as item(s) 1

* *Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.*

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):*

ISA / EP

Request to use results of earlier search; reference to that search *(if an earlier search has been carried out by or requested from the International Searching Authority):*

Date (day/month/year)	Number	Country (or regional Office)
3 May 2000	SN 33945 NL	NL

Box No. VIII CHECK LIST; LANGUAGE OF FILING

This international application contains the following **number of sheets**:

request	: 3
description (excluding sequence listing part)	: 14
claims	: 2
abstract	: 1
drawings	:
sequence listing part of description	:
Total number of sheets	: 20

This international application is **accompanied by** the item(s) marked below:

1. ☒ fee calculation sheet
2. ☐ separate signed power of attorney
3. ☐ copy of general power of attorney; reference number, if any:
4. ☐ statement explaining lack of signature
5. ☐ priority document(s) identified in Box No. VI as item(s):
6. ☐ translation of international application into (language):
7. ☐ separate indications concerning deposited microorganism or other biological materia
8. ☐ nucleotide and/or amino acid sequence listing in computer readable form
9. ☐ other *(specify)*:

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

M. J. Hatzmann

For receiving Office use only

24 AUG 2000

1. Date of actual receipt of the purported international application:	(24.08.00)
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA /	6. ☐ Transmittal of search copy delayed until search fee is paid.

2. Drawings: ☐ received: ☐ not received:

For International Bureau use only

Date of receipt of the record copy by the International Bureau: 18 SEPTEMBER 2000 (18.09.00)

Titel: Werkwijze voor het maken van een tandheelkundig element

De uitvinding heeft betrekking op een werkwijze voor het maken van een functioneel tandheelkundig element en op een tandheelkundig element dat verkregen kan worden middels genoemde werkwijze.

Tandheelkundige elementen, zoals kronen, worden in de klinische praktijk voornamelijk toegepast voor het vervangen of corrigeren van tandstructuren. Het kan hierbij gaan om geheel of gedeeltelijk verloren gegane tanden of kiezen. Tot op heden werden materialen voor dergelijke elementen met name onderzocht op technologische/fysische en chemische eigenschappen. Tegenwoordig speelt daarnaast het biologische aspect een groeiende rol.

Tandheelkundige elementen kunnen worden vervaardigd van verschillende materialen. Voorbeelden hiervan zijn polymeren, metalen, composieten, combinaties van porselein en metaal, porselein en andere keramische materialen. Glazen en keramische materialen vormen een ideale groep van materialen voor tandheelkundige elementen, omdat ze hard zijn, een hoge slijtweerstand hebben, chemisch inert zijn in veel milieus (biocompatibiliteit), en eenvoudig kunnen worden gevormd tot een esthetisch tandheelkundig element. Een brede toepassing van deze materialen wordt echter tegengewerkt door de inherente brosheid die dikwijls het gevolg is van beperkingen in het productieproces en van de materiaalkeuze. Recente ontwikkelingen hebben tot verschillende keramische systemen geleid, zoals gesinterde keramiek, met glas geïnfiltreerd keramiek en glas-keramiek van uiteenlopende samenstellingen, die minder bros zijn.

De vervaardiging van tandheelkundige elementen is in de praktijk een ingewikkelde en tijdrovende aangelegenheid. Het gaat om producten die op individuele basis worden vervaardigd, omdat de precieze vorm van het element immers voor elke tand of kies in ieder individu anders is. Conventionele technieken die zijn toegepast, maken veelal

gebruik van een mal. Aangezien deze doorgaans slechts eenmalig gebruikt kan worden, zal duidelijk zijn dat deze technieken zeer kostbaar zijn.

In het verleden zijn wel technieken voorgesteld waarmee het mogelijk zou zijn om het vervaardigingsproces van tandheelkundige elementen te vereenvoudigen. Zo is door Abe et al., in Int. J. Japan Soc. Prec. Eng., vol. 30, no. 3, 1996, blz. 278-279, voorgesteld een selectieve laser-sintering (SLS) uit te voeren met titanium. Bij deze techniek treedt echter vaak krimp op. Ook kunnen er micro-cracks ontstaan, hetgeen de techniek ongeschikt maakt voor vervaardiging van functionele tandheelkundige elementen. In de Europese octrooiaanvrage 0 311 214 is voorgesteld om een kroon te maken met behulp van frezen. Frezen biedt niet de mogelijkheid om gekleurde elementen te maken. Bovendien is de keuze voor geschikte materialen die door frezen kunnen worden bewerkt beperkt. Zoals gezegd, vormen keramische materialen een ideale groep materialen voor het vervaardigen van tandheelkundige elementen, omdat ze hard, zeer slijtvast en onder veel omstandigheden inert zijn.

Het Amerikaanse octrooischrift 5.690.490 beschrijft een methode voor het vervaardigen van een pasmodel voor een tandheelkundig element door zgn. 'pinhead molding'. De methode behelst het gebruik van een soort matrixprint-techniek, waarbij materiaal wordt opgespoten. De printer wordt aangestuurd met een CAD/CAM programma. De gegevens waar dit programma gebruik van maakt, zijn verkregen uit een laserscan van de tand of de kies die moet worden vervangen.

In het Amerikaanse octrooischrift 5.823.778 wordt een werkwijze beschreven voor het vervaardigen van een tandheelkundig element waarbij een indruk van het gebit van een patiënt wordt verkregen, die vervolgens als mal wordt gebruikt om een gebitselement na te maken. Dit element wordt in laagjes afgebroken en elk laagje wordt gescand om

drie dimensionaal computermodel van het gebitselement te verkrijgen.

De onderhavige uitvinding beoogt een techniek te verschaffen waarmee functionele tandheelkundige elementen op een flexibele en efficiënte wijze kunnen worden vervaardigd. Voorts wordt beoogd dat de techniek geen gebruik maakt van een mal en dat het mogelijk is om tandheelkundige elementen van polymeer, metaal of keramisch materiaal, of van combinaties daarvan te maken.

Verrassenderwijs is thans gevonden dat de gestelde doelen worden bereikt door een tandheelkundig element te vervaardigen onder toepassing van een driedimensionale druktechniek.

Driedimensionale druktechnieken zijn op zich bekend. Deze zijn onder meer beschreven in de Europese octrooi-aanvrage 0 431 924, het Amerikaanse octrooischrift 5.902.441 en de internationale octrooiaanvragen 94/19112, 97/26302 en 98/51747. Voor een beschrijving van de details van de techniek wordt verwezen naar de genoemde documenten, welke dan ook als hierin ingelast beschouwd dienen te worden.

De werkwijze volgens de uitvinding is in beginsel geschikt om alle typen tandheelkundige elementen te vervaardigen. Voorbeelden hiervan zijn kronen, (voor- en zijtanden), inlays, overlays, onlays, deelkronen, fixaties en veneers.

Bij voorkeur wordt bij een patiënt, waarbij een tandheelkundig element vervangen/geplaatst dient te worden, eerst nauwkeurig opgemeten welke vorm het element moet hebben. Hierbij zal, indien mogelijk, dikwijls worden uitgegaan van de vorm van de tand of kies, of het gedeelte daarvan, dat aan vervanging toe is. Het heeft de voorkeur dat het opmeten kan plaatsvinden op een wijze die de patiënt zo min mogelijk ongemak bezorgt. Bijzonder geschikte technieken voor het opmeten van de vorm voor het tandheelkundige element maken gebruik van optische

scantechnieken, in het bijzonder het gebruik van lasers. Hierbij worden in elektronische vorm gegevens verkregen over de gewenste vorm en afmetingen, die direct gevisualiseerd kunnen worden in een computer. De elektronische gegevens over de vorm en afmetingen van het tandheelkundige element worden bij voorkeur door een computer aangewend om de uitvoering van de driedimensionale druktechniek aan te sturen. Een andere geschikte methode voor het opmeten is volgens de CEREC-techniek, Sirona Dental Systems GmbH, Bensheim, Duitsland.

In de driedimensionale druktechniek wordt een geschikt materiaal achtereenvolgens in laagjes aangebracht, waarbij specifieke stappen worden genomen om ervoor te zorgen dat elk laagje slechts op bepaalde gewenste plaatsen hecht op het voorafgaande laagje. Deze specifieke stappen worden bepaald door de gewenste vorm van het tandheelkundige element en bij voorkeur aangestuurd door bovengenoemde elektronische gegevens.

Volgens de uitvinding wordt bij genoemde specifieke stappen gebruik gemaakt van een bindmiddel. Dit bindmiddel wordt slechts op de gewenste specifieke plaatsen aangebracht op een voorafgaand laagje. Wanneer op het bindmiddel een laagje van, bijvoorbeeld, keramisch materiaal waarvan het tandheelkundige element moet worden gevormd, wordt aangebracht, zal dit slechts op de gewenste plaatsen hechten. Het niet hechtende poeder, dat dus niet in contact komt met het bindmiddel, kan eenvoudig worden verwijderd.

Het bindmiddel wordt bij voorkeur op de gewenste plaatsen aangebracht met behulp van een printkop, aangestuurd door de computer op basis van de gegevens verkregen bij het opmeten. Vervolgens wordt een poeder van het materiaal dat is gekozen voor de vervaardiging van het tandheelkundige element aangebracht.

Het is ook mogelijk om ondersteboven te werken en een laagje bindmiddel aan de onderkant van een plaat aan te

brengen en vervolgens het bindmiddel te dippen in het poeder. In deze laatste variant kunnen eenvoudig verschillende soorten poeder voor verschillende laagjes worden gebruikt. Het poeder zal in beide gevallen alleen binden op plaatsen waar bindmiddel is aangebracht. Door deze stappen voldoende vaak te herhalen wordt uiteindelijk de gewenste vorm van het tandheelkundige element verkregen. Het bindmiddel kan tenslotte verwijderd worden door te sinteren.

Volgens een alternatief voor deze methode wordt eerst los poeder in een poederbed gelegd, en wordt vervolgens lokaal bindmiddel aangebracht om op de gewenste plaatsen binding te verkrijgen. In feite kunnen bindmiddel en poeder dus in elke volgorde worden aangebracht.

De ondergrond waarop wordt gewerkt, kan gevormd worden door enkele lagen los poeder, zodat het te vormen tandheelkundige element gemakkelijk van de ondergrond los te maken is. Bij het sinteren wordt bij voorkeur een niet-hechtende ondergrond, bijvoorbeeld een metalen plaat, gebruikt.

Dankzij de nauwkeurigheid van de gegevens die verkregen kunnen worden door het opmeten met behulp van een lasertechniek, en dankzij de nauwkeurigheid waarmee een computer, op basis van die gegevens, een printkop kan aansturen, kunnen op zeer nauwkeurige wijze de gewenste vorm en afmetingen van het tandheelkundige element verkregen worden. Was het bij de ouderwetse technieken nodig om een tandheelkundig element diverse malen bij te vormen nadat het was gevormd in een mal, zo kan bij de werkwijze volgens de uitvinding doorgaans volstaan worden met een enkele keer bijvormen. Afhankelijk van het materiaal dat is gekozen voor het tandheelkundige element, kan dit bijvormen gedaan worden door te slijpen, vijlen, polijsten, schuren, stralen of door gebruik te maken van een kogelbed (een trillende bak met abrasieve kogels).

Het bindmiddel dat gebruikt wordt in een werkwijze volgens de uitvinding dient oplosbaar te zijn in een geschikt oplosmiddel tot een oplossing met een viscositeit van 1-40 mPas, bij voorkeur circa 3 mPas, en een beladingsgraad van 3-10 gew.%. Aldus heeft het bindmiddel bij voorkeur een relatief laag molecuulgewicht. Voorbeelden van geschikte bindmiddelen zijn colloïdale silica, polyvinylacetaat (PVA), zetmeellijmen, acrylaten, polyvinylalcohol, polyethyleenoxide (PEO), ethyleenvinylacetaat (EVA) en derivaten daarvan.

In het bindmiddel zal veelal een kleurstof worden toegepast. Geschikte kleurstoffen zijn doorgaans gebaseerd op anorganische pigmenten met een hoog gehalte aan SiO_2, waardoor ze hittebestendig zijn. Deze stoffen zijn op zich bekend en bijvoorbeeld commercieel verkrijgbaar bij Carmen, Espident GmbH, Ispringen, Duitsland of VITA Zahnfabrik H. Rauter GmbH & co., Bad Zäckingen, Duitsland. Bij voorkeur worden één of meer van de volgende kleurstoffen gebruikt: SiO, CoO, ZnO, Cr_2O_3, TiO_2, Sb_2O_3, Fe_2O_3 en MnO_2. Kleurstoffen worden, afhankelijk van de gewenste tandkleur, bij voorkeur gebruikt in hoeveelheden tot 10 gew.%, betrokken op het gewicht van het poeder. Het is een bijzonder voordeel van de uitvinding dat op verschillende plaatsen in het tandheelkundige element verschillende kleuren kunnen worden toegepast, desgewenst met een doorzichtige buitenlaag, hetgeen een natuurlijke optische dieptewerking met zich meebrengt. Dankzij deze en andere voordelen lijkt een tandheelkundig element buitengewoon waarheidsgetrouw op een echte tand of kies.

Dit bindmiddel kan, zoals gezegd, met een printkop op een geschikte ondergrond worden aangebracht. De printkop wordt aangestuurd door een computer op basis van de gegevens die zijn verkregen bij het aanmeten van het tandheelkundige element bij een patiënt. Voorbeelden van geschikte printkoppen zijn bijvoorbeeld inkjetkoppen van het continue of van het drop-on-demand type. De printkop

heeft bij voorkeur een spuitmond met een diameter tussen 10 en 100 μm, bij bijzondere voorkeur tussen 25 en 75 μm en een lengte tussen 50 en 150 μm.

Het poeder dat gebruikt wordt, wordt gekozen aan de hand van het materiaal waarvan het tandheelkundige element uiteindelijk gemaakt dient te zijn. Het poeder kan zowel in droge vorm als in gedispergeerde vorm (slurrie) worden gebruikt. Dispersies worden bij voorkeur bereid in water of een waterige oplossing. Daarnaast kunnen sommige organische oplosmiddelen, zoals isopropanol, worden gebruikt. De vakman zal op basis van zijn normale kennis een geschikt oplosmiddel kunnen kiezen. Afhankelijk van de deeltjesgrootte van het poeder kan het gewenst zijn om een colloïdale oplossing van het poeder te bereiden, bijvoorbeeld door toevoeging van een base, zout en/of surfactant. Wanneer het poeder in gedispergeerde vorm wordt aangebracht, vindt bij voorkeur telkens een droogstap plaats voordat een volgend laagje wordt aangebracht.

Volgens een voorkeursuitvoeringsvorm van de uitvinding worden in elk laagje meerdere materialen, van verschillende aard, toegepast. Ook is het mogelijk, en onder omstandigheden zeer gunstig, om de samenstelling van het poeder te wijzigen per aan te brengen laagje. Indien er één type materiaal per laag wordt toegepast, wordt veelal een doctor blading/strijkmes (slurrie) of counter rotating roller (droog poeder) gebruikt. Indien er meer dan één type materiaal per laag wordt toegepast wordt dit lokaal aangebracht, bij voorkeur middels een of meerder computergestuurde nozzles die een of meerdere materialen aan kunnen brengen. De materialen kunnen van elkaar verschillen in kleur of in eigenschappen, waarbij gedacht kan worden aan (di)elektrische of piëzo-eigenschappen. Volgens deze uitvoeringsvorm wordt het materiaal bij voorkeur in de vorm van een slurrie aangebracht.

Volgens de uitvinding kunnen verschillende soorten materialen, met name zowel keramische materialen als

metalen, worden toegepast. Om het materiaal goed te kunnen aanbrengen op het bindmiddel, is het materiaal bij voorkeur in poedervorm. Afhankelijk van de grootte van de poederdeeltjes zal het poeder in droge vorm of in gedispergeerde vorm (slurrie) worden aangebracht. Hierbij geldt dat een fijner poeder leidt tot een grotere nauwkeurigheid bij het bereiken van de gewenste vorm van het tandheelkundige element. Bij voorkeur heeft het poeder een gemiddelde deeltjesgrootte (diameter) tussen 1 nm en 50 μm, bij bijzondere voorkeur kleiner dan 50 nm, nog liever tussen 10 nm en 25 nm. Het voordeel hiervan is dat de sintering kort en bij relatief lage temperatuur kan worden uitgevoerd. Gevonden is dat de genoemde deeltjesgrootte een positief effect heeft op de vorm en sinterbaarheid van het te vormen tandheelkundig element.

Het poeder kan van elk materiaal zijn dat gebruikelijkerwijs wordt toegepast voor het vormen van tandheelkundige elementen. Hiervoor zijn met name metalen en keramische materialen en combinaties daarvan geschikt.

Wanneer een keramisch materiaal wordt gebruikt ter vorming van het tandheelkundige element, wordt dit bij voorkeur gekozen uit de groep van SiO_2 , Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O en combinaties daarvan. Eventueel kunnen keramische samenstellingen nog F of P_2O_5 bevatten. Bijzonder geschikte keramische materialen zijn de commercieel verkrijgbare samenstellingen Vitadur®, IPS Empress®, Dicor®, IPS Empress II®, Cerestone®, CerePearl® en In-Ceram®.

Wanneer een metaal wordt gebruikt ter vorming van het tandheelkundige element, wordt dit bij voorkeur gekozen uit de groep van legeringen van goud, platina, palladium, nikkel, chroom, ijzer, aluminium, molybdeen, beryllium, koper, magnesium, kobalt en tin. Eventueel kan een dergelijke legering silicium bevatten. Voor een beschrijving van geschikte legeringen wordt verwezen naar

J.P. Moffa, Alternatives to Gold Alloys in Dentistry, DHEW Publication N. (NIH), 77-1227.

Desgewenst kan er een smeermiddel aan het poeder worden toegevoegd om het aanbrengen in laagjes van het poeder te vergemakkelijken. Voorbeelden van geschikte smeermiddelen zijn stearinezuur of afgeleide stearaten, zoals zink- of calciumstearaat. Een smeermiddel wordt bij voorkeur toegepast in een hoeveelheid van 1-2 gew.%, betrokken op het gewicht van het poeder.

Zoals gezegd, wordt bij voorkeur afwisselend een laagje bindmiddel aangebracht en een laagje poeder daarop aangebracht. De dikte van de laagjes poeder ligt bij voorkeur tussen 0,01 en 0,3 mm, bij bijzondere voorkeur tussen 20 en 100 µm, hetgeen de oppervlaktekwaliteit bij geringe hoogtecontourverschillen van de laagjes ten goede komt. De hoeveelheid bindmiddel per oppervlakte-eenheid poeder komt redelijk nauw, maar kan eenvoudig door een vakman worden aangepast aan de aard van het gebruikte bindmiddel en poeder. Doorgaans zal de hoeveelheid bindmiddel liggen tussen 0,005 en 0,3 gram per vierkante centimeter poeder. Aldus wordt laagje voor laagje het gewenste tandheelkundige element opgebouwd.

Wanneer het laatste laagje is aangebracht, wordt overtollig poeder, dat niet is gebonden verwijderd. Dit kan worden gedaan door het gehele poederbed uit te nemen, op zijn kop te draaien en licht te schudden. Restjes kunnen worden verwijderd door te blazen, bijvoorbeeld met perslucht. Daarna kunnen de poederdeeltjes aan elkaar gebonden worden door te sinteren. Bij voorkeur wordt voorafgaand aan de sintering een "debinding" stap uitgevoerd. Hiermee wordt een behandeling ter verwijdering van het bindmiddel bedoeld. Debinding kan worden uitgevoerd met behulp van warmte of een geschikt oplosmiddel, zoals hexaan. Omdat de meeste bindmiddelen een relatief complexe samenstelling hebben, vindt debinding bij voorkeur plaats door te verwarmen met behulp van een temperatuurtraject

(bijvoorbeeld van 20-500°C). Een dergelijk verwarmingstraject kan eenvoudig worden gekoppeld aan een sinterstap.

De duur en temperatuur waarbij wordt gesinterd zal afhangen van de aard van het gebruikte bindmiddel en het poeder. Doorgaans zal de duur van het sinteren tussen 10 minuten en 3 uur bedragen, terwijl de temperatuur gewoonlijk tussen 400 en 800°C zal liggen. Door zodanig te sinteren dat alleen necks gevormd worden is de krimp door de sinterstap minimaal/verwaarloosbaar. Eventueel is deze krimp te compenseren door het CAD model te schalen.

Na de sintering wordt het verkregen product bij voorkeur geïnfiltreerd, waarbij een tweede fase in het product wordt gebracht. Hierdoor wordt de porositeit van het product aanzienlijk verlaagd. Dichtheden tot boven de 99% zijn haalbaar. De infiltratie kan bijvoorbeeld in een oven worden uitgevoerd, waarbij het infiltratiemateriaal tegen het tandheelkundige element wordt aangelegd. Het infiltratiemateriaal smelt bij een lagere temperatuur dan het materiaal van het tandheelkundige element. Door capillaire werking wordt het vloeibare infiltratiemateriaal als het ware naar binnen gezogen (geadsorbeerd). Deze stap duurt relatief kort en geeft het tandheelkundige element de gewenste eigenschappen. Een geschikt materiaal hiervoor is bijvoorbeeld glas-keramiek of een polymeer. Bij voorkeur wordt een materiaal gebruikt dat is goedgekeurd voor gebruik in tandheelkundige elementen, als beschreven in de standaard ADA nr. 15 ANSY MD156.15-1962, die hierin als ingelast dient te worden beschouwd.

In bepaalde gevallen is het van voordeel gebleken om het tandheelkundige element te onderwerpen aan een thermische/chemische nabehandeling, zodat een optimale materiaal (micro) structuur wordt bereikt. Aldus wordt bij voorkeur het tandheelkundige element kortstondig verwarmd tot een temperatuur tussen 60 en 150°C, bij bijzondere voorkeur tussen 80 en 130°C.

In plaats daarvan, of in aanvulling daarop wordt bij voorkeur een thermische verdichting bewerkstelligd. Daartoe wordt het tandheelkundige element verwarmd tot een temperatuur van ten minste 250°C, bij voorkeur ten minste 400°C en nog liever ten minste 500°C. Deze behandeling draagt eraan bij dat het tandheelkundige element bijzonder gunstige eigenschappen krijgt.

Wanneer op één van de hierboven beschreven wijzen het tandheelkundige element is gevormd, kan het voorkomen dat dit nog enigszins bijgevormd moet worden. Zoals al is aangegeven is het een voordeel van de uitvinding dat zeer nauwkeurig gewerkt kan worden. Het bijvormen zal daarom minder omslachtig zijn dan bij de tot op heden toegepaste technieken. Wijzen waarop het bijvormen kan worden uitgevoerd zijn onder meer slijpen, vijlen, polijsten, schuren, stralen of behandelen met een kogelbed, afhankelijk van het gekozen materiaal van het tandheelkundige element.

De uitvinding zal thans nader worden toegelicht aan de hand van de volgende voorbeelden.

Voorbeeld 1

Twee bindmiddelen werden bereid met de volgende samenstellingen:

A:	- polyvinylacetaat (Optapix PA 4 G)	2 gew.%
	- alcoholgehalte (ethanol)	36 gew.%
	- glycol	2 gew.%
	- water	rest
B:	- polyvinylacetaat (Optapix PA 4 G)	2 gew.%
	- alcoholgehalte (ethanol)	34 gew.%
	- glycol	1 gew.%
	- water	rest.

De samenstellingen werden bereid door handmatig toevoegen van de ingrediënten en roeren. Het oplossen van het polyvinylacetaat duurde 6 à 10 uur. Met behulp van het alcoholgehalte kon de oppervlaktespanning worden ingesteld (een lage oppervlaktespanning bleek gunstig).

Voorbeeld 2

Met een bindjetprinter (Z402 van de firma Z Corporation, Burlington MA, USA) werden twee cilinders vervaardigd. Hierbij werd aluminapoeder (type CT 3000SG) gebruikt in combinatie met, achtereenvolgens, bindmiddel A en bindmiddel B (zie voorbeeld 1). De eigenschappen van het poeder zijn als volgt:

Tabel 1: Chemische zuiverheid (gewichts %)

Al_2O_3	>= 99.7
Na_2O	0.09
SiO_2	0.02
Fe_2O_3	0.02
CaO	0.02
MgO	0.10

Fysische eigenschappen van het poeder:

- Specifieke oppervlakte energie range BET:
  5.5 tot 7.5 m^2/g
- Gemiddelde deeltjesgrootte (MPS) d50:
  0.5 tot 0.7 µm Cilas 850
- Deeltjesgrootte d90:
  1.0 tot 2.0 µm Cilas 850

Keramische eigenschappen van het poeder:

- Groene dichtheid: 2.22 g/cm^3
- Gesinterde dichtheid: 3.90 g/cm^3
- Krimp: 16.5%

Het aluminapoeder wordt homogeen verdeeld over het bouwplateau middels een verdeler (soort scheermes/sneeuwschuiver/doctor blade). Vervolgens wordt de aangebrachte

laag los poeder gecompacteerd met een gecoate roller (teflon roller met polyesther top laag), zodat een gladde en vlakke laag los poeder ontstaat (als geplette poedersuiker). Door deze compactiestap wordt de initiële porositeit een stuk lager, wat de zgn. groene sterkte ten goede komt. De laagdikte van deze poederlaag is instelbaar en is hier op 0.0625 mm ingesteld (deze stapgrootte bepaalt de nauwkeurigheid van het volgen van de productcontouren en kan nog kleiner).

Nadat het gehele bouwoppervlak van een nieuwe gecompacteerde poederlaag is voorzien, wordt met behulp van een binderjetprinter (Z402 van de firma Z Corp., zie ook WO-A-97/26302) lokaal op het losse poeder bindmiddel aangebracht. De locatie waar de bindersubstantie geprint moet worden is tevoren softwarematig bepaald. Het bindmiddel dringt zo diep het losse poeder binnen dat de poederdeeltjes in de nieuwe laag met elkaar verbonden worden en dat tevens de nieuwe laag aan de voorgaande gehecht wordt.

Er is met de gebruikte cartridge en bindersubstantie een optimum in bindmiddelhoeveelheid gevonden bij 10x printen per 100 g. De hoeveelheid binder is bij gegeven laagdikte 0.0017 g/cm^2 per inkjectrun. Bij een 10x inkjetten is dit dus 0.017 g/cm^2, wat leidt tot een goede consistentie van de producten (ze zijn hanteerbaar).

Door de recoating en inkjetstappen te herhalen wordt uiteindelijk het gehele product opgebouwd in de groene (= met bindmiddel) vorm.

De cilindervormige producten die geproduceerd zijn hadden een diameter van 16.4 mm en een hoogte van 18 mm; de massa is 5.3 g. De experimenten zijn in drievoud uitgevoerd. De porositeit van de alumina cilinders is maximaal 45% (bij niet compacteren). Compacteren leidt tot een lagere porositeit (schatting 55 - 70%).

De tussenproducten zijn vervolgens gedebind en gesinterd volgens een specifiek temperatuur - tijd traject,

waarbij werd verhit met een snelheid van 120°C per uur tot een temperatuur van 1200°C. Deze temperatuur werd gedurende 120 minuten gehandhaafd, waarna werd afgekoeld tot kamertemperatuur met opnieuw een snelheid van 120°C per uur. De gesinterde producten worden vervolgens geïnfiltreerd met een glaskeramiek om de uiteindelijke sterkte en mechanische eigenschappen te verkrijgen. De verkregen eigenschappen voldoen aan de aan de functionele tandelementen gestelde norm.

PCT/NL 00/00585

CONCLUSIES

1. Werkwijze voor het vervaardigen van een functioneel tandheelkundig element, waarbij een driedimensionale druktechniek wordt toegepast.

2. Werkwijze volgens conclusie 1, waarbij de vorm en afmetingen van het tandheelkundige element worden opgemeten bij een patiënt onder toepassing van een optische scantechniek, bij voorkeur een lasertechniek.

3. Werkwijze volgens conclusie 2, waarbij de lasertechniek gegevens over vorm en afmetingen in elektronische vorm oplevert.

4. Werkwijze volgens één van de voorafgaande conclusies, waarbij laagjes van een geschikt materiaal achtereenvolgens op elkaar worden aangebracht, waarbij maatregelen worden getroffen zodanig dat elk laagje op gewenste plaatsen aan een voorafgaand laagje hecht en overtollig, niet-hechtend materiaal wordt verwijderd.

5. Werkwijze volgens conclusie 4, waarbij het geschikte materiaal een poeder is en waarbij de hechting tussen de laagjes wordt gerealiseerd met behulp van een bindmiddel.

6. Werkwijze volgens conclusie 5, waarbij een computer wordt toegepast om, op basis van de gegevens verkregen bij het opmeten, een printkop aan te sturen die het bindmiddel op specifieke, gewenste plaatsen aanbrengt.

7. Werkwijze volgens conclusies 5 of 6, waarbij het bindmiddel wordt gekozen uit de groep van colloïdale silica, polyvinylacetaat (PVA), zetmeellijmen, acrylaten, polyvinylalcohol, polyethyleenoxide (PEO), ethyleenvinylacetaat (EVA) en derivaten daarvan.

8. Werkwijze volgens conclusies 5-7, waarbij het poeder wordt gekozen uit de groep van keramische materialen, zoals SiO_2, Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O en combinaties daarvan, en metalen, zoals legeringen van goud, platina, palladium, nikkel, chroom, ijzer, aluminium, molybdeen, beryllium, koper,

magnesium, kobalt en tin, en combinaties van metalen en keramische materialen.

9. Werkwijze volgens een van de conclusies 5-8, waarbij de laagjes met een doctor blading/strijkmes worden aangebracht.

10. Werkwijze volgens conclusies 5-9, waarbij het poeder wordt in gedispergeerde vorm.

11. Werkwijze volgens conclusie 10, waarbij in een laagje poeders van verschillende aard worden gebruikt.

12. Werkwijze volgens conclusie 11, waarbij in een laagje poeders van verschillende kleur worden gebruikt.

13. Werkwijze volgens conclusie 10-12, waarbij ten minste één laagje in samenstelling verschilt van de andere

14. Werkwijze volgens conclusie 11-13, waarbij het poeder lokaal wordt aangebracht met een computer gestuurde nozzle.

15. Werkwijze volgens conclusies 5-14, waarbij het tandheelkundige element wordt gesinterd bij een temperatuur van 400-800°C gedurende een periode tussen 10 minuten en 3 uur.

16. Werkwijze volgens conclusie 15, waarbij na het sinteren een infiltratie met glas-keramiek of een polymeer wordt uitgevoerd.

17. Werkwijze volgens één van de voorafgaande conclusies, waarbij het tandheelkundige element wordt bijgevormd door te slijpen, vijlen, polijsten, schuren, stralen of behandelen met een kogelbed.

18. Tandheelkundig element verkrijgbaar middels een werkwijze volgens één van de voorafgaande conclusies.

UITTREKSEL

De onderhavige uitvinding heeft betrekking op een werkwijze voor het vervaardigen van een functioneel tandheelkundig element, zoals een kroon. Volgens de uitvinding wordt hierbij gebruik gemaakt van een driedimensionale druktechniek. De grote voordelen van de uitvinding zijn dat er geen mal meer nodig is, hetgeen een aanzienlijke kostenbesparing met zich meebrengt, dat een grote nauwkeurigheid bereikt wordt en dat het element van verschillende materialen kan worden gemaakt.

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 01 March 2001 (01.03.01)	
International application No.: PCT/NL00/00585	Applicant's or agent's file reference: P49296PC00
International filing date: 24 August 2000 (24.08.00)	Priority date: 24 August 1999 (24.08.99)
Applicant: FEENSTRA, Frits, Kornelis	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

12 January 2001 (12.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer:

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Telephone No.: (41-22) 338.83.38

14

PATENT COOPERATION TREATY

REC'D 27 NOV 2001
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
P49296PC00		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/NL00/00585	24/08/2000	24/08/1999
International Patent Classification (IPC) or national classification and IPC A61C13/00		
Applicant NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUUR...et		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 6 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/01/2001	23.11.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Pypen, C Telephone No. +49 89 2399 2799

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL00/00585

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-12	as originally filed				

Claims, No.:

1-20	as received on	05/11/2001	with letter of	05/11/2001	

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☐ the claims, Nos.:
   - ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 20.

because:

☒ the said international application, or the said claims Nos. 20 relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-19
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-19
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-19

No: Claims

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Reference is made to the following documents:

D1: US-A-5 690 490 (BOYD GEORGE H ET AL) 25 November 1997

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

Claim 20 is a so-called "product-by-process" claim. Such claims are admissible only if the products themselves fulfil the requirements for patentability (T150/82, OJ 1984, 309). The subject-matter of claim 20, a dental element, is known from document D1 (abstract) and therefor is not new.

Re Item V

Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Document D1 (column 5, lines 47-51) discloses a method for fabricating a functional dental element, wherein a three-dimensional printing technique is used, from which the subject-matter of the independent claim 1 differs in that the element is subjected to infiltration by a second phase.

1.1. In none of the documents cited in the search report, the infiltration of the dental element with a second phase in order to enhance the material characteristics is not found, nor is this step suggested.

1.2. The subject-matter of independent claim 1 is therefore novel, involves an inventive step, and is industrially applicable (Article 33(2)-(4) PCT).

2. The independent claims 2-19 define particular embodiments of the invention according to claim 1.
Therefore, these claims also meet the requirements of Art. 33 (2)-(4)PCT, in combination with claim 1.

Re Item VII

Certain defects in the international application

1. The independent claim 1 should have been worded in the two-part form, with those features known in combination from the prior art (documents D1) being placed in the preamble and with the remaining features being included in the characterizing part (Rule 6.3(b)PCT, decision of the Board of Appeal T 13/84).

Re Item VIII

Certain observations on the international application

1. The subject-matter of the claims 1-4, 17-18 of the initial application appears to be the same as the subject-matter of the claims 1-4, 12-13 of the initial application NI00/00586.

Amended Claims

1. A method for fabricating a functional dental element, wherein a three-dimensional printing technique is used and wherein the element is subjected to infiltration by a second phase.

2. A method according to claim 1, wherein the infiltration is preceded by a debinding step and/or a sintering step.

3. A method according to claim 1 or 2, wherein the shape and dimensions of the dental element are measured in a patient while using an optical scan technique, preferably a laser technique.

4. A method according to claim 3, wherein the laser technique yields data about shape and dimensions in electronic form.

5. A method according to any one of the preceding claims, wherein layers of a suitable material are successively applied onto each other by three-dimensional printing and wherein each layer is bonded at desired positions to a preceding layer thereby allowing the removal of excess, non-adhering material.

6. A method according to claim 5, wherein the suitable material is a powder and wherein the bonding between the layers is realized by means of a binder.

7. A method according to claim 6, wherein a computer is used for controlling, on the basis of the data obtained upon measuring, a print head which applies the binder to specific, desired positions.

8. A method according to claim 6 or 7, wherein the binder is selected from the group of colloidal silica, polyvinyl acetate (PVA), starch adhesives, acrylates, polyvinyl alcohol, polyethylene oxide (PEO), ethylenevinyl acetate (EVA) and derivatives thereof.

9. A method according to claims 6-8, wherein the powder is selected from the group of ceramic materials, such as SiO_2, Al_2O_3, K_2O, Na_2O, CaO, Ba_2O, CrO_2, TiO_2, BaO, CeO_2, La_2O_3, MgO, ZnO, Li_2O and combinations thereof, and metals, such as alloys of gold, platinum, palladium, nickel, chromium, iron, aluminum, molybdenum,

beryllium, copper, magnesium, cobalt and tin, and combinations of metals and ceramic materials.

10. A method according to any one of claims 6-9, wherein the layers are applied with a doctor blade.

11. A method according to claims 6-10, wherein the powder is applied in dispersed form.

12. A method according to claim 11, wherein in a layer, powders of a different nature are used.

13. A method according to claim 12, wherein in a layer, powders of a different color are used.

14. A method according to claims 11-13, wherein at least one layer differs in composition from the others.

15. A method according to claims 12-14, wherein the powder is locally applied with a computer-controlled nozzle.

16. A method according to claims 12-15, wherein at least one of the powders has an average particle size less than 50 nm.

17. A method according to any one of the preceding claims, wherein the dental element is sintered at a temperature of 400-800 °C for a period between 10 minutes and 3 hours.

18. A method according to claim 17, wherein after sintering an infiltration with a glass-ceramic or a polymer is carried out.

19. A method according to any one of the preceding claims, wherein the dental element is additionally shaped by grinding, filing, polishing, sanding, blasting or treatment with a ball bed.

20. A dental element obtainable by a method according to any one of the preceding claims.